

A COMPARATIVE ANALYSIS OF PRESSURE AND SPEED ON VOLUMETRIC EFFICIENCY AND DISCHARGE OF THE RECIPROCATING PUMP

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Abstract: The experiment conducted at Mahamaya College of Agricultural Engineering & Technology, Ambedkarnagar (U.P.). The pump tested for analysis performance is ELGIMACE model no. LLO3022 single acting reciprocating pump equipped with 2HP three phase induction electric motor with 1440rpm. A hose measuring of water source of 4.12x3.25x1.23. G.I.20 mm size, suction pipe was used. The delivery pipe was high density pliable reinforced rubber pipe to withstand abundant pressure (up to 25kg/cm²). Stop watch was measuring discharge of 1/100sec. of least count. For three different speeds of 242 rpm, 285 rpm and 344 rpm with five dissimilar pressures are 1.5 kg/cm², 5.7 kg/cm², 10.3kg/cm², 15kg/cm² and 24kg/cm², pump was tested. Track record of all pipe pressure used for this testing was measured by a pressure gauge having adequacy 0-35kg/cm. In motor shaft a V(twin) belt the electric connection was energized and a pulley with minimum diameter 6.25cm was fitted. The outcomes based on the exploratory observation showed that the efficiency rises when pressure is rises. At speed of 344 rpm the efficiency is detected 90% and at dupe speed the volumetric efficiency is 77% for least pressure 1.5kg/cm and volumetric efficiency is 95% for maximum pressure 24 kg/cm². The discharge increases as pressure goes up and it is showed by the average discharge and pressure, which is almost linear. The relationship sequence is mostly same for all above circumstances; this stated that discharge is mutual to the pressure for a reciprocating pump.

Index Terms: Discharge, Efficiency, Volumetric efficiency, Pressure, rpm, Static head, Reciprocal and Pressure head.

I. INTRODUCTION

Reciprocating pump is a pneumatic machine which gets converted in hydraulic energy from mechanical energy. A cylinder containing a reciprocating piston absorbs liquid which expend a thrust (impel) force on the liquid and hike its hydraulic energy (pressure energy of liquid). It's a kind of positive displacement pump which comprises of piston or plunger. It is used at a place where relatively small amount of water is to be delivered at high pressure. Water in cylinder is displaced by the movement of piston for the functioning of reciprocating pump. Valves control the flow. A piston or plunger is cylindrical piece which moves backward and forward inside hollow cylinder. Reciprocating pump's capacity depend on the sizes of cylinder chamber, piston length and piston stroke. Electric motor engine operate a pump which have to come into prominence in a large lift irrigation schemes, high output levels can be quickly attained and managed by this process. Reciprocating pump generates high head, but their capacity is smaller compared to other types of pump. Reciprocating pump works on single acting independent suction and discharge strokes works on double acting suction and they discharge in both the direction. Although, recommendation of specific purpose pumps is very tough due to the inaccurate figures about scientific information such as efficiency discharge, head relation and other characteristics. Understanding all this circumstances, under laboratory conditions a study was approached for evaluation of volumetric efficiency, pressure discharge relationship and speed-power-discharge.

II. MATERIALS AND METHODS

At Mahamaya College of Agricultural Engineering and Technology, Ambedkarnagar (U.P.) an experiment was conducted. An ELGIMACE model single acting reciprocating pump equipped with 2HP, three phase induction electric motor with 1440 rpm was tested for analysis performance. The water source was a hose measuring 4.12x3.25x1.23. A G.I.20 mm of suction pipe was used. The delivery pipe was high density flexible reinforced rubber pipe to widths and sufficient pressure (up to 25 kg/cm²). Stop watch measured a discharge of 1/100sec.least count. In a cylindrical vessel of 69.91 liter capacity discharge was collected. The pump was tested for three different speeds of 242 rpm, 285 rpm and 344 rpm along with different pressures of 1.5kg/cm², 5.7kg/cm², 10.3kg/cm², 15 kg/cm² and 24kg/cm². For contemporary users indeed requirements advanced engineering techniques were used for testing in reciprocating pump. The pressure variation was measured with a pressure gauge having 0-35 kg/cm². With conversion factor 1kg/cm² =10 meter, the pressure head was converted into static head. The pulley with minimum diameter 6.25 cm was fitted in motor shaft a V-(twin) belt the electric connection was energized. When whole air of the suction pipe was out of the flexible delivery pipe than after few seconds pump started taking revolutions and discharge suction pipe air. The pressure was fitted to the delivery pipe with the help of spitted clip having nuts and bolts at the both end was restarted and discharge was collected in the measuring tank, at the same time, time was recorded with the help of stop watch. Pump power units are WHP (Watt Horsepower) and SHP (Shaft Horse Power). Watt Horse Power is the theoretical horse power required for pumping. Horse power is the unit or term in which head and capacity of the pump is expressed. Given below is an equation for the computation volumetric efficiency of pump–

$$\text{Volumetric efficiency} = \frac{\text{Actual Volume}}{\text{Theoretical Volume}} * 100$$

Or,

$$\text{Volumetric efficiency} = \frac{\text{Actual Volume}}{\frac{\pi}{4}(d^2)L*\frac{n}{60}} * 100$$

Where, d is the diameter of the cylinder (met.), L, is the length of stroke (met.) and n, is the pump speed (rpm) and WHP is calculated by using formulae-

$$\text{WHP} = \frac{\text{Discharge (liter / sec.)} * \text{Total dynamic head (m)}}{75}$$

Table 1. Pressure – Discharge – Volumetric Efficiency relationship in reciprocating pump

S.N.	Pressure (kg/cm ²)	Discharge(lit/sec)	Actual Value (m ³)	Theoretical Volume (m ³)	Volumetric efficiency (%)
Speed 242 rpm					
1.	1.5	0.13	0.00013		43
2.	5.7	0.18	0.00018		60
3.	10.3	0.21	0.00021	0.00030	70
4.	15	0.25	0.00025		83
5.	24	0.27	0.00027		90
Speed 285 rpm					
1.	1.5	0.14	0.00014		42
2.	5.7	0.21	0.00021		63
3.	10.3	0.24	0.00024	0.00033	72
4.	15	0.28	0.00028		84
5.	24	0.30	0.00030		90
Speed 344rpm					
1.	1.5	0.37	0.00037		77
2.	5.7	0.39	0.00039		81
3.	10.3	0.41	0.00041	0.00048	85
4.	15	0.44	0.00044		91
5.	24	0.46	0.00046		95

Fig.1 Efficiency-Discharge relationship of reciprocating pump tested, speed: 242rpm.

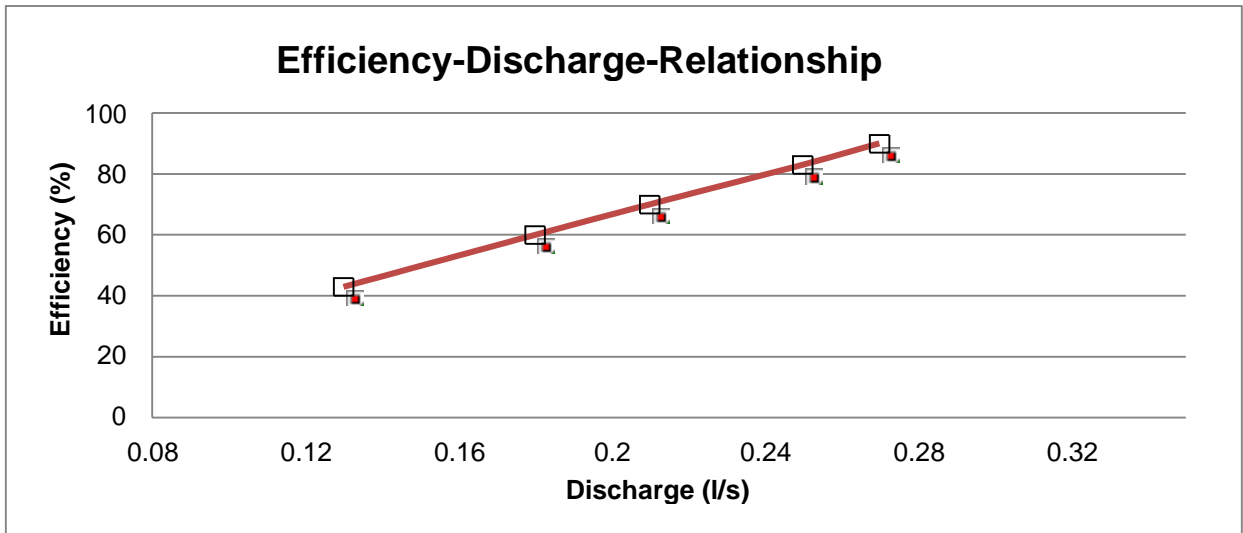


Fig.2 Efficiency-Discharge relationship of reciprocating pump tested, speed: 285rpm

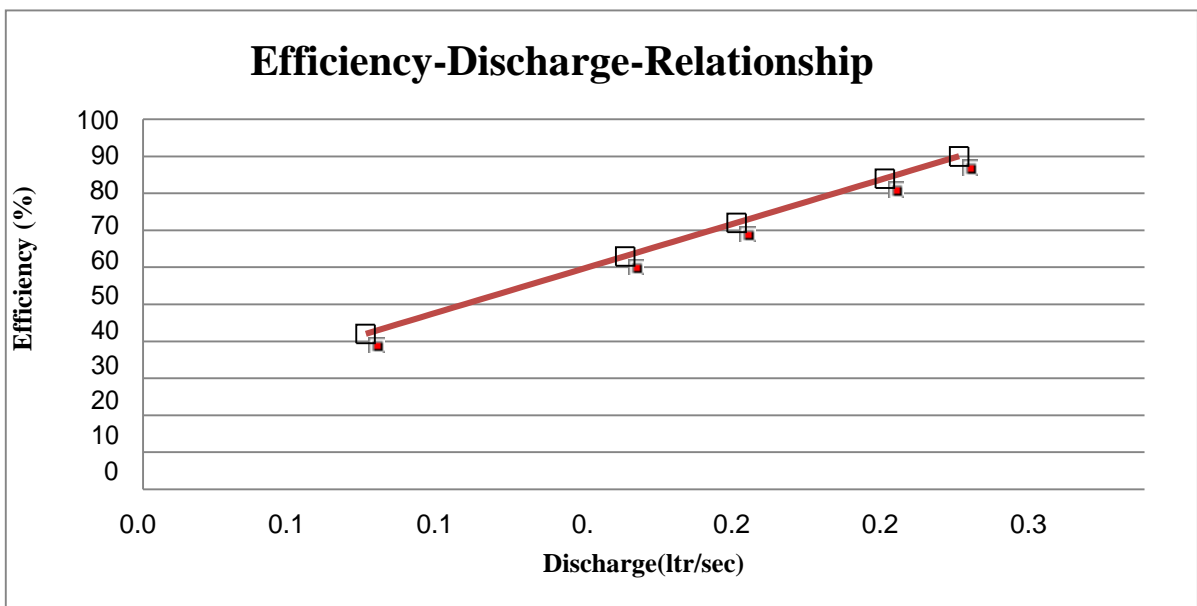


Fig.3 Efficiency-Discharge relationship of reciprocating pump tested, speed: 344 rpm

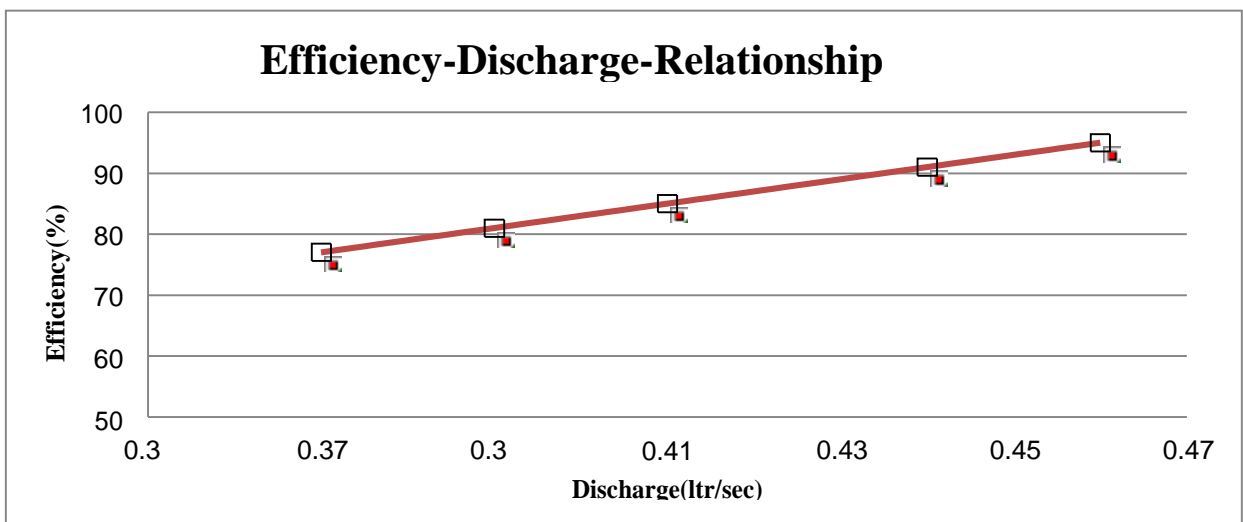


Table 2. Power, Pressure, Discharge and Efficiency for different speeds of reciprocating pump.

S.N.	Power, Watt	Pressure (kg/cm ²)	Discharge (l/sec)	Efficiency (%)
Speed ,242rpm				
1.	56.15	1.5	0.27	
2.	261.98	5.7	0.25	
3.	352.46	10.3	0.21	70
4.	499.43	15	0.18	
5.	506.16	24	0.13	
Speed ,285 rpm				
1.	61.78	1.5	0.30	
2.	251.73	5.7	0.28	
3.	377.19	10.3	0.24	70.2
4.	472.9	15	0.21	
5.	564.04	24	0.14	
Speed ,344 rpm				
1.	83.31	1.5	0.46	
2.	362.22	5.7	0.44	
3.	678.71	10.3	0.41	85.8
4.	997.93	15	0.39	
5	1356.21	24	0.37	

Fig4. Pressure-Discharge relationship of reciprocating pump tested, speed: 242rpm

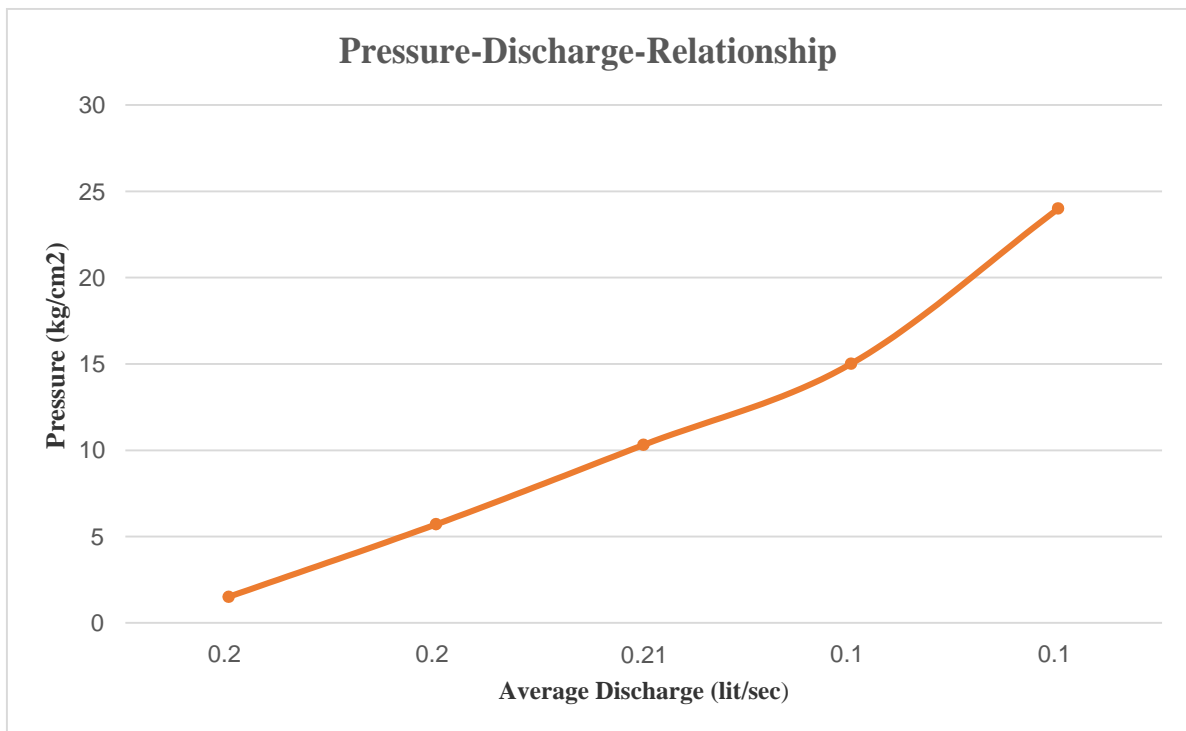


Fig.5 Pressure-Discharge relationship of reciprocating pump tested, speed: 285rpm

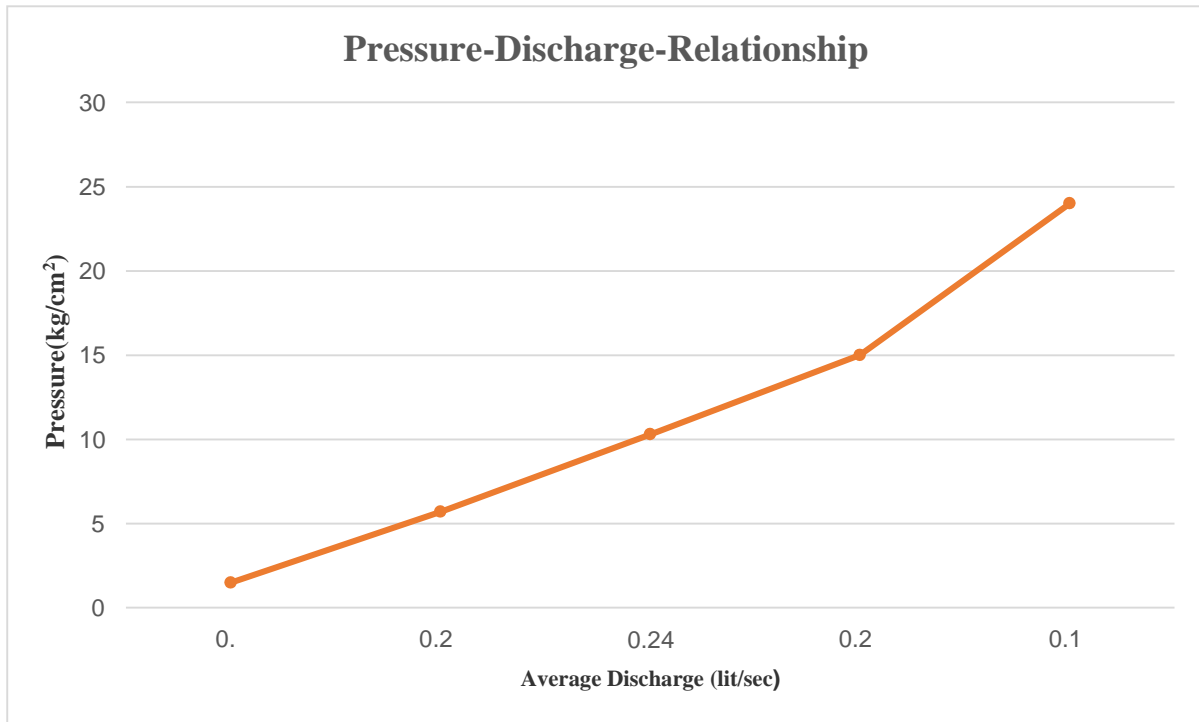
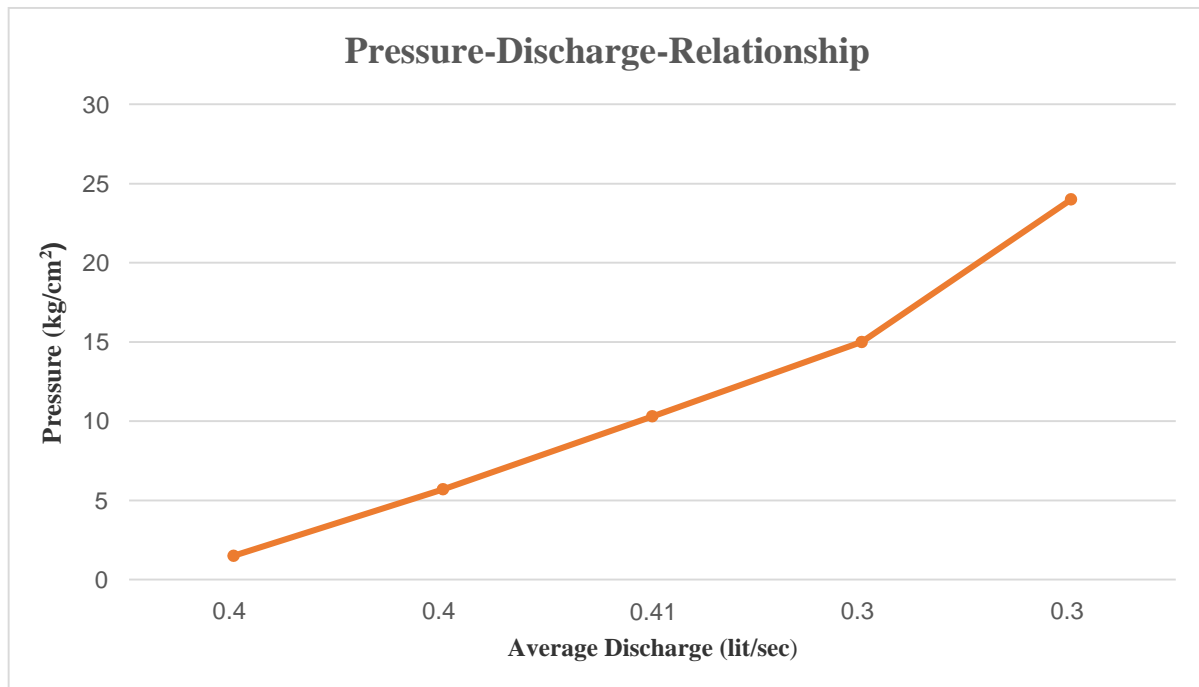


Fig6. Pressure-Discharge relationship of reciprocating pump tested, speed: 344rpm



III. RESULTS AND DISCUSSION

The analysis was conducted of speed on the volumetric efficiency, effect of pressure and discharge of reciprocating pump on the basis of speed-power-discharge relationship, volumetric efficiency and pressure discharge relationship. The pump was tested for five distinct pressures i.e. 1.5 kg/cm², 5.7 kg/cm², 10.3 kg/cm², 15 kg/cm² and 24 kg/cm² with three different speed of 285 rpm, 344 rpm and 242 rpm. The results stated that the volumetric efficiency and discharge

rate both increases simultaneously if pressure increased at different speed. The volumetric efficiency is 43% at speed of 242 rpm, at pressure 1.5 kg/cm² while the volumetric efficiency is 90% at pressure of 24 kg/cm². Similarly we get the same result at speed of 285 rpm and 344 rpm. Discharge at pressure 1.5 kg/cm², 24 kg/cm², 1.5 kg/cm² and 24 kg/cm² is 0.13 l/sec, 0.27 l/sec, 0.37 l/sec and 0.46 l/sec respectively. Similarly results revealed that power (Watt) and discharge are directly proportional. At speed 242 rpm and power 506.16 watt the pump efficiency is 70 %, at speed 285 rpm and power 564.04 the pump efficiency is 70.2 % and at speed 344 rpm and power 1356.21 watt, the pump efficiency is 85.8 %. Therefore directly proportional or increasing kind of relationship was found between pressure and discharge. As pressure increases, power consumption also increases and as the discharge start decreasing than the power required and pressure build up forms a linear kind of relationship.

IV. SUMMARY AND CONCLUSION

This whole experiment was conducted to find out reciprocating pump's discharge and the effect of pressure and speed on the volumetric efficiency. The pump was tested for three different speed i.e. 242 rpm, 285 rpm and 344 rpm with five different pressures i.e. 1.5 kg/cm², 5.7 kg/cm², 10.3 kg/cm², 15 kg/cm² and 24 kg/cm². Efficiency, discharge and power of reciprocating pump were determined by the help of inconsistency parameters which are named as pump speed and pressure.

The execution evaluated that-

1. The volumetric efficiency of the pump is directly proportional to delivery head.
The volumetric efficiency is 43% at a speed of 242 rpm and low pressure of 1.5 kg/cm². Consequently at high pressure of 24 kg/cm² the volumetric efficiency is 90 %.
 - At speed 285 rpm and at low pressure of 1.5 kg/cm² the volumetric efficiency is 42%, whereas at high pressure of 24 kg/cm² the volumetric efficiency is 90%.
 - At speed 344 rpm, at low pressure of 1.5 kg/cm² the volumetric efficiency is 77%, ensuing at high pressure of 24 kg/cm² the volumetric efficiency is 95%.
2. The average volumetric efficiency for three different pump speed are-
 - At speed 242 rpm the average volumetric efficiency is 70 % for power 56.15 -506.16Watt and pressure 1.5 -24 kg/cm².
 - At speed 285 rpm the average volumetric efficiency is 70.2 % for power 61.78 -564.04 Watt and pressure 1.5 – 24 kg/cm².
 - At speed 344 rpm the average volumetric efficiency is 85.8 % for power 83.31.-1356...21Watt and pressure 1.5 -24 kg/cm².
3. The increase trend was sorted in association of the increase in pressure and its analogous discharge.
4. Increase of pressure tends to more power consumption and a linear relation was found among pressure build up and the power required, while the discharge chased decreasing trend.

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